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Journal of Geological Education

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THE ART OF GEOLOGY

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ABSTRACT. Geology, unlike most other sciences, is still dominated by the descriptive phase, and much time must be spent accumulating facts about the earth. Interpretation of these facts presents complex problems involving a large number of variables, which can never be represented adequately by mathematical formulae or physical models. In other words, geology is as much an art as it is a science, and solution of its problems requires imagination as well as vast accumulations of facts.

INTRODUCTION

Recently a colleague in another field remarked that "geology is not a science." This paper is not intended to be a rebuttal of that categorical statement, since I believe than in many ways geology, like medicine, is as much an art as it is a science.[1] The remark and the succeeding discussion did, however, indicate a lack of knowledge of the fields and techniques of geology that, as a geologist, I naturally deplore. Perhaps this situation exists because geology does differ from most other sciences. It is important for geology teachers to be fully aware of the ways in which it differs and to be able to present these to their non-geological colleagues as well as to their students; for it is these very differences that make geology effective in economic fields where engineers, mathematicians, and physicists can fail.

THOUGHT PROCESSES IN SCIENCE

It is not easy to dissect the thought processes used in the pursuit of science—or art. This is certainly evidenced by the diversity and dissension among the various schools of psychological thought. But one can at least make the attempt, with salutary results at least in regard to the development of humility.

Reasoning can be conscious or unconscious. We sometimes think that conscious inference is the dominant form, but many if not most of the truly great discoveries have been made unconsciously, by insight, strokes of genius, or spontaneous illumination. These subconscious shortcuts have undoubtedly played a larger part in the development of science than the "reasonable" scientist likes to admit.

Conscious reasoning can also be divided into inductive (from special cases to general laws) and deductive (from general laws to special cases). There are other similar techniques of conscious inference, such as analogy (from similar cases),

[1] Webster's *Collegiate Dictionary* gives nine definitions of "art," number three being "a branch of learning, a science"; and number nine being "systematic application of knowledge or skill in effecting a desired result." Definition number five for "science" is "art or skill regarded as the result of knowledge of laws and principles." So it appears that even the lexicographers do not care to distinguish closely between the two! Furthermore, nowhere in any of the definitions of science is there any indication of the necessity for mathematical formulation in science. I think I would even be safe in saying that mathematics can be more logically classified as philosophy than as a science!

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generalization (grouping into a larger class), specialization (dividing into smaller classes), and recently the application of the theory of probability as used to test statistical hypotheses. All these have recently been called the "logic of discovery," whereas deductive reasoning has been called the "logic of proof."

DEVELOPMENT OF SCIENTIFIC LAWS

The life history of a scientific law might, somewhat facetiously, be divided, like the seven stages of man, into outrageous suggestion, tentative conjecture, credible proposition, plausible hypothesis, reasonable theory, accepted theory, and accepted law. Each reader, according to his own semantic background, will want to emend or change this list of terms. Most of the great geologic ideas have gone through some such history in their development. Consider, for example, the development of the concepts of marine submergence, fossils as ancient organisms, the superposition of strata, the origin of igneous rocks, stratigraphic correlation, uniformitarianism, granitization, isostasy, evolution, base level, the duration of geologic time. Each of these ideas has changed our concepts of the nature of the earth and its parts, of its processes, and of geologic time.

A physicist colleague of mine, Haro von Buttlar, has drawn up a list, shown in Table 1, of the various steps the physicist uses in developing a law. Alongside it I have presented a similar list for geology. The percentage figures represent an estimate of the relative amount of time spent in each step.

TABLE 1—STEPS IN DEVELOPING A SCIENTIFIC LAW

Physics		*Geology*	
1. Perception, investigation	25%	1. Perception, investigation	70%
2. Reflection, systematization	10%	2. Reflection, systematization	10%
3. Condensation to a curve		3. ———	
4. Formulation of relationship between measurable variables in terms of a mathematical formula	5%	4. Formulation of relationships or correlations, if any, between systematized groups of data	2%
5. Formulation of an explaining hypothesis	40%	5. Formulation of *all possible* explanations of relationships between groups of data	2%
6. Further experiments to test it	15%	6. Further investigations, based on working hypotheses and directed toward elimination of as many alternates as possible	15%
7. Establishing the law	5%		
8. Looking over many laws to find the basic laws	?%*		

* Einstein took a lifetime!

GEOLOGY COMPARED WITH OTHER SCIENCES

An important difference between geology and many other sciences is the relatively large amount of time that must be spent by the geologist in collecting data (see point 1 in Table 1). In many disciplines of geology—e.g., mineralogy, crystallography, petrography, stratigraphy, sedimentation, volcanism, physiography, glacial geology—the descriptive phase still predominates. Other are semi-descriptive—e.g., structural geology, petrology, metamorphic geology, geomorphology, submarine geology, paleontology, economic geology. Most of the geologist's time is taken up with the compilation of an adequate description of that part of the earth's crust with which he is concerned.

There is no necessity for mathematical formulation in most of the disciplines

of geology (although it *is* being used more and more, with highly variable results). Note that point 3 is omitted from the geology list in Table 1, and that in point 4 the physicist's "formulation of a relationship between measurable variables in terms of a mathematical formula" is replaced with "correlations between systematized groups of data." This is necessary, as I shall point out later, because of the complexity of geological problems and the large number of variables involved, many of which are not measurable at the present time.

In point 5, whereas the physicist formulates one explaining hypothesis, the geologist formulates *all possible* explanations. In geology we call this, after T. C. Chamberlain who first formulated it, the "method of multiple working hypotheses." Speaking now as a field geologist, I can say that it is necessary and practical and that it works. A geologist moves among a swarm of alternate possibilities. Each bit of additional information collected either adds to his belief in one or more hypotheses, suggests new ones, or eliminates old ones from the realm of possibility. Very few, if any, of the problems facing a geologist are so simple that he can solve them by a single method of approach. Furthermore, his final solution, based upon the necessarily incomplete data which he has available, usually consists of several alternates, each of which is still valid, none of which can be eliminated from the picture. This, perhaps, explains why geologists have the reputation of being great qualifiers, and why a geologist who is too positive in his opinions is looked at askance by his brethren.

GEOLOGIC THOUGHT LIKENED TO A BANYAN TREE

Thinking in terms of four dimensions (that is, three in space and one in time), as most geologists must of necessity do, I am in the habit of constructing physical models for geological ideas, and I spent some time trying to construct a model to illustrate this process of geologic thought. Finally I decided upon the familiar idea of the pattern or image of a tree. Each leaf on the tree represents an isolated fact. As one starts at the top of the tree and moves a horizontal plane of investigation downwards, the facts begin to coordinate and become organized into patterns of twigs (systematized ideas) and branches (hypotheses). Separate hypotheses then combine and integrate to show a larger and larger picture as new facts (leaves) and ideas (twigs) come to light. Various hypotheses then begin to govern the direction, one way or another, of the investigation and tend to develop new facts. So far, so good. But my tree did not show what happened to the abandoned and disproven hypotheses, until one of my co-workers suggested the banyan tree of India, which puts down numerous aerial roots from its branches, a few of which reach the ground to form new root systems. This completed the image, even to the extent of suggesting the various residual alternate hypotheses that remain after one has reached the ground and exhausted all the available data.

COMPLEXITIES OF GEOLOGIC PROBLEMS

To illustrate, now, the complexity of even the most simple problems in geology, let us take a single hand specimen of sandstone. This piece of rock is made up of several minerals, each of which is characterized by a different chemical composition, specific gravity, hardness, toughness, and has a more or less definite cleavage or lack of cleavage. Each grain has a definite size, frequently different from any other, and there are varying proportions of the different grain sizes and varying relation-

ships between grain size and mineral species. Each grain may have a unique shape, expressed in terms of roundness, sphericity, and angularity. Each grain may have a varying surface texture and degree of polish and may be altered in a different way or to a different degree.

This swarm of data must be interpreted in terms of the past history of the rock, for the chief purpose of geology is to reconstruct the past. The listed characteristics of the rock particles are a result of some of the following factors, which affected them during their history:

1. Conditions at source: kind of source rock; rate at which it was eroded; climate, vegetation, and soil at source.
2. Conditions of transportation: agent—air, water, ice, etc.; distance carried; climatic, physical, and chemical environment during transportation.
3. Conditions of deposition: if on land, the climate and vegetation of the area and the agent of deposition; if in water, its depth, chemical composition, and degree of movement.
4. Later alteration: diagenesis, silification, dolomitization, etc.

Similarly complex problems of interpretation can be met with in any field of geology. An additional example is the interpretation of underground conditions from surface outcrops and geophysical surveys. The method of attacking the problem is dependent on the geologist's previous training and experience. As a result, no two geologists will submit identical interpretations, and in many cases widely divergent interpretations are submitted based on the same field data. Specific examples of such differing interpretations have been presented by Theodore Link[2] in a paper that may be useful to those readers who want to demonstrate this aspect of geology to non-geologists.

CONCLUSION

I challenge any mathematician or mathematical physicist to set up a formula that will coordinate into an integrated picture of the past all the variables involved in the formation of a sandstone! Nor can a geological model ever reveal all the true facts of structure and outcrops. The multiple variables always presented by the four-dimensional facts of earth can never be adequately duplicated to form a perfect analogous model. The restricted regimens of mathematics, physics, and chemistry, valuable as they are, can never completely summarize and analyze any complicated geological phenomenon. Only the unlimited scope of man's imagination, governed, regulated, and channeled by generations of accumulated fac ., can hope to solve earth's problems.

[2] Link, Theodore A., 1949, Interpretations of foothills structures, Alberta, Canada: Am. Assoc. Petroleum Geologists Bull., v. 33, p. 1475–1501.

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WHAT IS GEOLOGIC TRUTH?*
RESPONSE ON RECEIVING THE NEIL MINER TEACHING AWARD

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ABSTRACT. Geological identifications of minerals, fossils, stratigraphic succession, and the like may be analyzed in terms of operations and, if certain precautions are taken, the conclusions may be considered correct by definition. Historical implications are less easily tested for accuracy. For simple problems, however, such as the source direction for the San Onofre breccia of southern California, or the subaerial or subaqueous origin of the head of Monterey Submarine Canyon, the method of multiple hypotheses can be made exhaustive and apparently conclusive.

I thank the Association most heartily for this high honor. I am especially proud to follow the two men who have previously received the Award.

When our President notified me of the Award he suggested a few remarks, with emphasis on the few. I shall try to stay within bounds by dealing with matters that require only a small amount of factual background. I shall talk about things that I have often discussed with students. I have found, however, that what I spend fifteen minutes on here—and enough, you will say—must in teaching practice be spread over a year or more.

We are geologists because we love beautiful mineral specimens or fine fossils or magnificent mountains. I myself turned from soil science to petrography so that I could spend my life looking at interference colors. But we find it necessary to describe and label things. We call one thing tourmaline, another *Olenellus*. How do we know we are right? With respect to minerals or fossils, we can say that our conclusions are correct by definition (even though, for fossils, the definition may be a special one, peculiar to ourselves). A substance is tourmaline because it has the properties of tourmaline. Of course, a long series of observations and tests preceded the differentiation of sharply defined minerals. But now the procedure is a simple country cousin of Bridgman's test of physical theory by operational analysis. Essentially the method *is* Bridgman's. A definition is formulated, and then it is applied. The formulation of the definition of tourmaline may have been in terms of the operations of chemical and crystallographic, or X-ray, analyses. Nevertheless, we may identify the mineral by its less obviously fundamental optical properties and still feel confident of the result, because of close correlation established by numerous previous trials. On this level we usually reach unanimous agreement—and (on this level) agreement is another way of saying that truth has been attained, is it not?

As long as we stick to the description of things seen we feel reasonably safe. We finish up with labelled specimens or geologic maps or the diagrams of structural petrology or the statement that in the walls of the Grand Canyon the Supai formation overlies the Redwall limestone. But geology is also a historical science. How do we justify our historical pronouncements? Were you there, Charlie?

* Presented on November 7, 1955, at the fifth annual meeting of the Association of Geology Teachers, at New Orleans, Louisiana.

How do we know what happened first, what second, what things at the same time? Huxley's doubts are perhaps not the only difficulties in this connection. And—if we try to go farther—how can we possibly know the appearance or even the general form of any landscape older than the present one? We must admit at once that a complete picture is impossible. Nevertheless, much of the geologist's fun comes from attempts to construct models, actual or in imagination, of past conditions on this planet.

For purposes of discussion let me take two examples from my own experience. The first concerns the mid-Miocene San Onofre breccia exposed for 40 miles along the southern California coast southeast of Los Angeles. The breccia mass is roughly wedge-shaped, with a maximum thickness of about 2500 feet near the shore and thinning to the vanishing point 5 to 10 miles east and inland. It is composed of clasts ranging in size from dust particles to blocks 15 feet long, and in most places these clasts are one and all fragments of glaucophane schist or related rocks. The breccia is intercalated in more ordinary sediments. It is part of an Upper Cretaceous–Tertiary sedimentary prism that is elongated NNW–SSE. It is underlain by sandstones, siltstones, and other sedimentary rocks, composed largely of quartz, feldspars, micas, and other minerals that are different, either intrinsically or in their inclusions, from those of the glaucophane schists. These underlying sediments are of great but unknown thickness (deep wells have not gone through them), and they extend farther north-northwest and south-southeast than does the breccia itself. The sedimentary prism is now only 10 or 12 miles wide and is bounded on the east (and underlain) by a crystalline basement composed of the granitic rocks assigned by Larsen to the southern California batholith, bordered by porphyritic and slaty rocks. This crystalline basement is made up of rocks that are mostly considered Mesozoic in age. The Mesozoic crystallines extend eastward a hundred miles or more and are then succeeded by a lithologically similar pre-Cambrian basement.

There is nothing like the glaucophane schists to the east, either in the adjacent basement complex or anywhere else between the sedimentary prism and the Atlantic Ocean. West of the present shore, however, beyond 20 miles of sea, lies Catalina Island, whose crystalline basement is composed of glaucophane schists and related rocks. Also, northwest of the area under consideration, in the broad, blunt peninsula at whose base Long Beach and San Pedro are built, a small exposure of glaucophane schist is to be found in the core of the Palos Verdes Hills.

With these facts before us we can say something about the provenance of the clasts in the San Onofre breccia. No statistical work is necessary. These clasts cannot possibly have been derived from the underlying sediments, from their north-northwest or south-southeast continuations, or from the eastern basement complex. The breccia clasts must have come from some part of the compass arc that spreads from northwest to south—in brief, from the west or southwest, from the place where the sea now is.

The conclusion just stated is acceptable on a common-sense basis, but critical analysis shows that it involves several assumptions. For one thing, we assume, as a non-essential convenience, that the geographic directions, commonly called compass directions, have not changed since San Onofre time. Second, we assume that the several rock formations in question have not changed their relative positions in

any important way since San Onofre time. Third, we assume the law of superposition, stated by Nicolaus Steno in 1669, which here means that the strata beneath the San Onofre breccia are older than the breccia and were in fact the substratum on which it was deposited.

Subject to these assumptions, the procedure used was exhaustive, made so by sharply limiting the objective. We considered source directions only, and we took in both the substratum and the full circle of the compass rose. This procedure avoids the difficulties encountered if one uses the method of multiple hypotheses in the ordinary geological fashion. We have not tried to draw a complete picture of southern California in San Onofre time. We have not even claimed that the schist source or the breccia itself was then above sea level. I think that the portions of the schist mass that were eroded away and most of the accumulating breccia too were above sea level. If I had more time I would be glad to tell you why I think so. But that is another problem. Its consideration would carry us into the discussion of the difficulties of distinguishing between continental and deep-sea breccias.

It was the year 1925 when I put into print the obvious: a suggestion of a western source for the San Onofre breccia. Since that time knowledge of the western glaucophane schist has expanded. Hundreds of wells drilled near the base of the Palos Verdes peninsula, and others widespread on the west side of the Los Angeles Basin, have passed through post-San Onofre sediments and reached a basement composed of glaucophane schist and related rocks. These new data have been welcome corroborations of the hypothesis of an extensive western mass of glaucophane schist, but I hardly felt them necessary. A schist source must have been present west or southwest of the San Onofre outcrops and south of the Los Angeles Basin in San Onofre time, no matter what the drilling in the Los Angeles Basin might turn up. Of course, the schist mass may have moved away since San Onofre time. It may even have gone to the Los Angeles Basin, travelling along a California strike-slip fault. The principal fault of the northwest-striking Newport–Inglewood zone may be such a fault. It is in just the right position. Strike-slip movement of this magnitude has not been demonstrated for it, but neither has such movement been proved impossible. This, however, is at present merely tectonic speculation; it must not be allowed to obscure the main point, the conclusion that the San Onofre breccia must have come from the west or southwest.

My second example is the realm of origin of the head of Monterey Submarine Canyon, off the central California coast, at the mouth of Salinas River. Lower Salinas River has a gradient of about .05 per cent; the head of the submarine canyon, just offshore, 11.5 per cent. The canyon head has a gradient more than 200 times as steep as that of the land valley. If a combined long profile is drawn with 20-fold exaggeration, Salinas Valley still looks practically horizontal but the uppermost part of the canyon profile becomes almost vertical. Both land valley and submarine canyon head are incised in weak sediments. If a person goes to Moss Beach, at the mouth of Salinas River and at the head of the submarine canyon, he can stand on the crumbling low sea cliff, composed of brown stream alluvium, right beside a well that went almost 8000 feet in sedimentary materials. The uppermost sediments are mostly stream alluvium, but at a few hundred feet depth they include some layers of sand with marine shells of Recent species.

Our problem is two-fold. First, the age of the submarine canyon head: was it

Recent, Pleistocene, or what? Second, the realm in which it originated: was it submarine or subaerial? As the age determination is really only a first step in getting at the origin, we can shorten the discussion by being legalistic and using a postulate concerning the exposed edges of strata that was another of the laws formulated by Steno in 1669. The submarine valley head seems to be pretty clearly incised into Pleistocene or Recent marine sediments or stream alluvium, just off the present shore. So, by Steno's postulate, it is itself no older than Pleistocene. With regard to submarine or subaerial origin we use a more fundamental postulate—the criterion of Hutton, Playfair, and Lyell—that the present is to be taken as the key to the past, with the assumption of uniformitarianism throughout the time represented by the geologic record. We can then perform a thought experiment. Lower sea level 300 feet and watch what happens to the exposed canyon head at the time of the next Salinas Valley flood. Think of this flood working as did New River in Imperial Valley silt in 1906, or San Antonio Creek in Los Angeles County alluvium in 1938. The Salinas River would cut back from its new mouth to the present one and beyond, at the rate of hundreds or thousands of feet per flood, establishing a new gradient only a little steeper than its present .05 per cent. That is, the 11.5 per cent gradient of the canyon head could not be maintained under subaerial conditions. Since a surface feature of the solid earth must have formed subaerially or subaqueously, the head of Monterey Submarine Canyon is of subaqueous and presumably submarine origin.

In this second example we have restricted our inquiry to a choice between two mutually exclusive alternatives. If one condition is shown to be impossible, the other must be correct. A skeptic might, however, wonder about the mental readjustments that would be necessary if *both* alternatives should be shown to be impossible.

Taking into account not only the two selected parts of problems that have been considered here, but the whole field of science, one may say that, first of all, complicated problems can usually be broken down into simple parts. Then each element can be attacked by one of several more or less rigorous methods. A solution may or may not be achieved; at the least the original complex problem will have been analyzed and its parts formulated. A solution, if found, may be (1) mathematically rigorous, (2) the sole surviving hypothesis, after exhausting other possibilities, (3) intuitive but fitting an extensive series of known facts, or (4) more or less doubtful. These statements are given here categorically but they can, I think, be justified inductively. My two examples belong in the second, or multiple hypotheses, group.

Finally, after struggling with such problems, the geologist relaxes with relief into his usual mood, where he is satisfied by candy-pink tourmaline, or sky-blue glaucophane, or the oceanic depth of his enjoyment of some other specific feature of the delightful world in which we live.

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THE HUMANITIES: AN ANTIDOTE FOR OVERSPECIALIZATION IN GEOLOGIC SCIENCE*

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ABSTRACT. Many undergraduate students take a large number of courses in geology at the expense of a well-balanced curriculum including courses in the humanities, social sciences, and basic sciences. Such undergraduate specialization may result in a first-rate technician but less often in a first-rate scientist and citizen. A broad and general education in the humanities is highly beneficial to the student by helping him to write and speak more effectively, by providing a basis for more effective human relationships, by challenging him to greater use of his talents, and by stimulating his intellectual interests.

During the last ten years there has been a larger amount of attention than usual paid to the undergraduate curriculum of the geology student. The opinions expressed by educators and professional men not in education have ranged from one extreme to another. Two published reports summarize the views of the Committees on Geologic Education of the Geological Society of America, the American Geological Institute, and the Association of Geology Teachers (Thiel et al., 1949 and 1950). These reports might be said to represent the "middle ground" between many rather extreme views. One of the most valuable results of this attention to the undergraduate curriculum has been to stimulate the interest of many teachers of geology in curriculum problems. It is disturbing to me, however, that most of the thinking has seemed to be concerned primarily with the technical training of the geologist. Also disturbing is the apparent trend in recent years toward more specialization in the undergraduate curriculum of many institutions, resulting in a woefully weak education in the humanities and social sciences.

During the last five years a number of leaders in the geologic profession and in other scientific disciplines have appealed to their colleagues in industry and education to become aware of the acute need for our scientists to be able to communicate effectively with both spoken and written words and to cultivate the ability to deal effectively with different peoples at all levels of human endeavor. I subscribe fully to the words of D. M. Davidson (1954, p. 347), who said: "We now have dozens of first-grade schools in North America turning out highly qualified men insofar as science is concerned, but, unfortunately, many of these are not well-rounded. They have scientific knowledge, but too little knowledge of how to handle themselves in their relationship with their fellow men." This need is increasing every day with the extension of frontiers of communication and transportation throughout the world and with the urgent and rapidly increasing dependence of our nation on other nations for all kinds of basic raw materials through trade. It is no longer reasonable to think that scientists can live in an isolated world where they have no responsibilities other than pursuing their own scientific interests. Today's world is one in which human relations may well be just as important as scientific

* Presented on November 7, 1955, at the fifth annual meeting of the Association of Geology Teachers at New Orleans, Louisiana. This paper was part of a symposium on the impact of General Education on the curriculum in geology.

techniques and one in which knowledge and appreciation of some of the major achievements of the world's great civilizations constitute a sound prerequisite for effective service and achievement in any field of science.

In my opinion, the undue weighting of an undergraduate curriculum for a geologist with courses in geology, with its consequent specialization at the undergraduate level, represents a warped educational perspective. In the first place, it indicates that the college or university—or at least the department—has for its primary goal the vocational training of the individual rather than a thorough and well-rounded education designed to develop the whole man. Secondly, it is a remarkably selfish and short-sighted approach even to vocational training in a field like geology. Undoubtedly a man so trained might qualify more readily for a job in some specialized field upon his graduation, and possibly also for a higher salary. In my opinion, few such trained men will rise as rapidly to the top of their profession, or even of their specialty, as those who have had an undergraduate educational background rich in the humanities and social sciences.

There are too many examples of scientists who have been excellently trained in their specialty and are capable of engaging competently in difficult research or of making precise observations and measurements and properly interpreting them but who find it almost impossible to convey the results to others, or to discuss them clearly, by written or spoken word. Possibly even worse is the scientist who is unable to deal effectively on a personal basis with those he meets, even with his colleagues, because there is no basis for mutual interest and understanding beyond the narrow confines of his special interest. Further, it is generally conceded that a scientist with a broad and varied background of training and experience will bring to bear on any problem a more profound knowledge, capable of handling unusual facets of the problem, than will one who has specialized narrowly.

Certainly I am not arguing against training in specialized fields but I am proposing that such training be reserved for graduate study. Nor am I arguing for something less than a thorough training in the fundamentals of the major areas of geologic science. This is essential so that the student may qualify both for jobs in the profession and for the finest graduate schools, where, if he desires, he may specialize to any extent. I am arguing strongly for a well-rounded education of our future geologists, one that will include a good background in the humanities and social sciences. A man so trained will be prepared better not only for making contributions in his own profession but also for making tangible contributions to the life of his community and nation and for more effectively leading a happy and fruitful life in any environment.

Implementing the basic philosophy of a well-rounded education at the undergraduate level is not always an easy thing to do. Even assuming a sympathetic attitude on the part of the institution's administration, there are many problems There is bound to be resistance from students whose sole interest is geology and more geology. Also, it may be difficult to guide each student into the proper courses that, for him, will represent a well-knit education in areas beyond his major interest.

Both of these difficulties were familiar to our geology staff at Franklin and Marshall College, and year after year we had attempted to cope with them on an individual basis, thinking it important to consider the nature and desires of each

student separately rather than to "press" them all into one academic mold. Inevitably there were some students who managed to complete their education with a bare minimum of courses in the humanities and social sciences and, in some cases, to take courses that did not augment their educational background. Fortunately, there were few such students; there would have been many had it not been for the personal interest and guidance of the staff. Nevertheless, there was a strongly felt need for an integrated program in the humanities which could be shared as a common experience by all students whose major interest was in geology or one of the other sciences. About four years ago such a program was initiated, consisting of three integrated courses that presuppose a first semester of English Composition and that span a two-year period. These are general courses, based on selected masterpieces of the world's greatest literature. The basic idea is that all great literature is contemporary and deals with the persistent problems and needs of man in any century and, hence, is relevant to our own times. Cross sections of the world's literature from ancient to modern times are chosen in accordance with topics expressing great human concerns, such as honor and glory, love, freedom and bondage, justice, tragedy, philosophy, etc. This program in the humanities may be taken with courses in a student's major field as well as other elected courses. Although it is not a required program, most of the geology students have been guided into it. Admittedly there have been some who have objected to the idea, but without exception all have been enthusiastic about the program after completing it.

We have followed closely the record of our graduates in graduate schools (to which most of them go) and in their professional jobs. Recognizing that it is difficult to be completely objective about a matter that has so many variables, I believe that those students with the best educational background in the humanities have been superior graduate students and have done unusually well in their jobs. Another matter worth reporting is the view expressed by many of these graduates, years after their graduation, of the value these non-geology, non-science courses have had for them. A summary of these views indicates two main values received from such courses: (1) they have provided a basis for intellectual interests and avocations that have yielded great personal satisfaction, and (2) they have provided a basis for satisfactory human relations and tangible contributions to the community, no matter what its size.

Institution of the humanities program at Franklin and Marshall College has greatly eased the difficulty of guiding the student toward a rich educational background in areas beyond his field of major interest. Obviously it has not solved all such problems. There is still a need to encourage the geology student—and other science students—to take courses in the social sciences and to indicate the advantages of beginning a second foreign language or of taking courses in philosophy and the arts rather than another geology course. Few students realize that, save for the excepitonal individual, these are the last years in which they may be intelligently introduced to and guided toward an appreciation of the vast heritage of knowledge of our great civilization.

Is it true that the graduate schools, which are rightly concerned with training men to a high degree of proficiency in a single discipline, and the employers in geologic surveys and in the oil, mining, and other industries really want men who are undergraduate-trained "specialists"? Do they want technicians rather than

educated men? I believe that they want a few such technicians, yes, but I cannot believe that those who guide the destiny of large companies and organizations desire this to be the goal of a college education for the young geologist, or the young scientist in any other discipline. Such an educational philosophy is one of restrictive proportions that does not treat with vision the latent potential of the man. What is needed is an educational philosophy that recognizes no limit to man's horizons; one that will stimulate and challenge the young student to the fullest use of his talents and ability; and one that will make him cognizant of the importance of all phases of human endeavor and their relation to each other. An educational environment predicated on such a philosophy will produce men of outstanding competence and leadership.

REFERENCES CITED

Davidson, D. M., 1954, Human relationships in future mineral procurement: Econ. Geol., v. 49, no. 4, p. 345–350.

Thiel, G. A. et al., 1949, Report of the committee on geologic education of the Geological Society of America: Interim Proc. Geol. Soc. of America, pt. 2, p. 17–21.

————, 1950, Geology curriculum in the liberal arts college: Interim Proc. Geol. Soc. of America, pt. 2, p. 9–17.

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VANNEVAR BUSH FELLOWSHIPS IN EARTH SCIENCES

The Department of Geology and Geophysics of the Massachusetts Institute of Technology and the Geophysical Laboratory of the Carnegie Institution of Washington are cooperating in the award of pre-doctoral fellowships in theoretical and experimental geology. The awards are to be known as the Vannevar Bush Fellowships in Earth Sciences, in honor of Dr. Bush, who long served as Professor, and later as Dean and Vice President, at M.I.T. and more recently as President of the Carnegie Institution of Washington.

Candidates for an award must have advanced training in mathematics, physics, and chemistry and a broad knowledge of the earth sciences. They must have completed all M.I.T. requirements for the Ph.D. degree except thesis and will be registered as full-time doctoral candidates at M.I.T. at all stages of their work. The fellowship will be awarded for the period (usually at least three or four terms) required by the recipient to complete his laboratory work at the Geophysical Laboratory and the subsequent time (one or more terms) required at M.I.T. for analyzing and correlating the data and completing the dissertation. The stipend will be $200 per month (plus appropriate tuition) for the first twelve months and $225 per month (plus tuition) for the duration of the fellowship.

Any graduate student interested in preparing for competition for the awards should write to the Chairman, Department of Geology and Geophysics, 24–302 M.I.T., Cambridge 39, Massachusetts for information about entrance requirements and possible financial assistance while meeting M.I.T. requirements.

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IS THERE ROOM FOR LIBERAL-EDUCATION COURSES IN THE GEOLOGY CURRICULUM?*

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ABSTRACT. The increase in the subject matter of geology in recent years and the need to add more courses to cover these fields have crowded the geology curriculum to the extent that many of the liberal-education courses formerly included are now omitted. Assuming that a liberal education is desirable for a well-rounded geologist, the colleges are faced with the possibility of: (1) lengthening the period of study from 4 years to 5 years, or even more, in order to include such courses, (2) leaving out some of the geology courses to make room for liberal-education courses, (3) setting up entrance requirements which would insure that much of the liberal education will be taken in high school, or (4)) some combination of the above proposals.

The emphasis today on graduate work in geology is largely an application of (1). Unfortunately, in many cases the geology content is increased without any increase in liberal-education content. The problem seems to narrow itself down to a consideration of "how much" geology is needed and "how much" liberal education is needed in a balanced curriculum. If these points can be answered the length of the course of study is automatically determined. Evidence supports the conclusion that much of the liberal education as well as the basic fundamentals, especially in mathematics and the sciences, can be done effectively in high school. The extent to which this can be done will correspondingly shorten the length of time required in college.

The subject of this symposium, "The Impact of General Education on the Curriculum in Geology," should be of interest to all who are teachers or administrators in our institutions of higher education, as well as to the business man who employs our product. I shall not attempt to define General Education, for here we would certainly find wide disagreement. But perhaps we can agree that a college education should do both of the following:

(1) It should train a sufficient number of persons to be competent in professions essential to society. This is the primary aim of specialized education, and it is so recognized in the development of professional schools.

(2) It should help the student towards intellectual and cultural attainments shared by all educated men, and it should equip him to assume the leadership in our complex society which is expected of the educated person. This second objective traditionally was called "liberal education," but recently the term "General Education" has been used, perhaps in contrast to "specialized" education.

I have been asked to discuss the question: "Is there room for liberal education in our geology curriculum?" My answer to this question is: If liberal education is of sufficient importance, we will *have* to make room for it, or perhaps I can rephrase the question to read: "Can we afford to neglect liberal education in our geology curriculum?" Many have answered this question—business executives as well as educational leaders. Without exception they agree that we cannot neglect liberal education and still equip our students for the leadership which is expected of them. Perhaps President James R. Killian of M.I.T. has expressed it as concisely as possible when, in a recent statement commenting on the shortage of scientists and

* Presented on November 7, 1955, at the fifth annual meeting of the Association of Geology Teachers at New Orleans, Louisiana. This paper was part of a symposium on the impact of General Education on the curriculum in geology.

engineers, he observed: "Employers are not just looking for 'bodies' with degrees—they are pressing the colleges for men and women with a more fundamental, integrated education in science, engineering, and the humanities. . . . They want men with the power to deal with the technologies of tomorrow, not of yesterday."[1]

The large corporations need, more than ever before, highly trained leaders. There is no longer the major emphasis on technological training, though it is necessary, but on a thorough grounding in the liberal arts. Since the new recruits, the products of our colleges, in many instances are deficient in this field of education, some of the larger corporations have set up schools to fill in this deficiency. As stated by Frederic E. Pamp (1955): "'The first question a company must now begin to ask of its candidates for executive responsibility is: 'What can you do that a computer can't?' . . . On one point all authorities have agreed. Narrow specialization is not enough. . . . There has been a growing call for 'breadth' in educational preparation for management, and a surprising degree of agreement on the need for more *liberal arts* in colleges."

Having established the need for liberal education in our geology curriculum, we now face the problem of how to accomplish this end.

The increase in the subject matter of geology in recent years and the need to add more courses to cover these fields have crowded the geology curriculum to the extent that many of the liberal-education courses, formerly included, are now omitted. Assuming that at least a minimum amount of liberal education is not only desirable but necessary for a well-rounded geologist, the colleges are faced with the problem of choosing one of the following: (1) Lengthening the period of study from four to five years, or even more, in order to include such courses. (2) Leaving out some of the geology courses to make room for liberal-education courses. (3) Setting up entrance requirements which would insure that much of the liberal education will be taken in high school. (4) Some combination of the above proposals.

The emphasis today on graduate work in geology is largely an application of the first proposal, namely, a lengthening of the period of study to more than four years. Unfortunately, in most cases the geology content is increased without any increase in liberal-education courses.

One great difficulty imposed on the college curriculum in geology is the necessity to teach basic but not college work, especially in English, elementary languages, and elementary mathematics. This requires time for work which may not be of college level, no matter how useful it may be as a training subject. The extent to which we can push these subjects back into the high school will correspondingly shorten the length of time required in college, or permit a greater "breadth" of work for the student in the time available. I think we would all be shocked to find how large a portion of our so-called college curriculum could (and should) be done in high school.

In regard to the suggestion that we leave out some of the geology courses to make room for liberal-education courses, I recommend that we critically examine the content of our courses and see if we cannot effect economies by omitting duplication between courses and actually eliminating some of the subject matter or entire courses if they deal with practical application rather than fundamentals.

[1] *Time Magazine*, Oct. 24, 1955.

Some of the practical applications which now make up significant segments of our courses could be learned much better in on-the-job training, and it is inefficient use of the student's time to include them in his formal courses. I am convinced that such a critical analysis will not only make more room in the geology curriculum but will actually improve it.

In conclusion I wish to answer the question, "Is there room for liberal education in our geology curriculum?" by saying, "We cannot afford to omit it." Therefore each college, within the limits of its own framework, must find ways to include it in the geology curriculum. This may take the form of entrance requirements to insure that the basic courses be taken in high school, thus freeing college time for other work, and it may involve limiting the content of our geology courses to the fundamentals. It is neither possible nor necessary to teach a student all there is to know about geology in his college courses. If we give him the fundamentals and the ability to think clearly and reason soundly, he is well prepared for the profession.

REFERENCES CITED

Pamp, Frederic E. Jr., 1955, Liberal arts as training for business: Harvard Business Review, v. 33, no. 3, p. 42–50.

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DISCUSSION

The excellent paper by C. M. Riley, "Cleavage, a Physical Property for the Identification of Minerals in Hand Specimen," in the Spring 1955 issue of the *Journal* emphasizes the importance of cleavage in determinative mineralogy and crystallography. It is surprising that so little attention has been given to this very informative property in contrast to other physical properties (e.g., color, hardness) which are so variable. An exception to this lack of emphasis on cleavage studies has been the teaching of mineralogy at the Michigan College of Mining and Technology, where A. E. Seaman and W. A. Seaman instituted a course in determinative mineralogy based primarily on cleavage and wrote a set of determinative tables to accompany the course. A discussion and review of the fourth edition of these tables has also been published (Staples, L. W., 1936, Review of "Mineral Classification according to Cleavage and Crystal Habit" by W. A. Seaman: Am. Mineralogist, v. 21, p. 139).

Dr. Riley's painstaking analysis of the relations of cleavage types and crystal systems is of great interest. It is to be hoped that further work may be done along this line, as for example, the development of a method for more quantitatively measuring the perfection of cleavage and then a tabulation of the number of species in each group having the same degree of perfection.

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GENERAL EDUCATION IN RETROSPECT*

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ABSTRACT. A few years ago the writer was connected with the department of geology in one of the universities in the Southwest at a time when a program of General Education was being introduced in the Arts and Sciences College of the university. It was the responsibility of the staff to formulate a curriculum and plan of instruction by which the General Education program could be interwoven into the curricula of the college.

One of the big obstacles of considerable concern was the possible modification of the existing geology curriculum and supporting courses. Most of the students who receive degrees in geology at that university go to work for oil companies, where they are in competition with graduates from other universities. The members of the staff felt a strong obligation to provide adequate training in geology for these students at a time when some of the industry's representatives were requiring a minimum of 50 hours of geology before the students would be considered for employment. Following numerous interdepartmental meetings and discussions, it appeared to the writer that not all the courses fundamental in the training of the geologist could be given in a four-year curriculum that included the proposed General Education courses.

In view of the country's need for technological advancement and the apparent shortage of students trained in certain technical fields, should the curriculum for geology majors be sacrificed for a General Education program? The question is not new.

General Education is a familiar term to many geology teachers today, either because they have been directly involved in such a program or because they have heard their friends discuss it. Some staff members may be in the midst of trying to integrate the General Education program with the geology curriculum, a few have had the program in operation for several years, and others may be faced with the problem in the future. Undoubtedly there are mixed reactions regarding the value of such a program, because of individual concepts of the training the student should receive and the requirements of a Bachelor's degree in geology by various schools.

It seems desirable to mention briefly some of the problems facing the staff members when plans for a General Education program were being formulated in the Arts and Sciences College of a university with which the writer was connected a few years ago. At that time it was explained to the departments of the physical sciences that the purpose of the General Education program was to provide cultural courses for students entering the college so they would have an appreciation of the arts and sciences in later life. Another purpose was to provide a broader training for students in the College of Education, who were planning to go into the teaching profession. These students would have the opportunity to acquire some knowledge of several sciences not available to them in their regular curricula. The principal problems introduced by adoption of a General Education program appeared to be two-fold: (1) The types of courses to be offered and how they should be taught. (2) The effect the program would have on the curricula in the sciences and the training of science students.

[1] Publication authorized by the Director, United States Geological Survey.

* Presented on November 7, 1955, at the fifth annual meeting of the Association of Geology Teachers at New Orleans, Louisiana. This paper was part of a symposium on the impact of General Education on the curriculum in geology.

Many interdepartmental discussions were held in an attempt to work out a program of special courses which would provide General Education training throughout the college. In the physical sciences the most favored proposal was a general integrated course of two semesters, including geology, chemistry, physics, and astronomy, with an equal amount of time allocated to the teaching of each of these physical sciences. Only the broad aspects of each science would be covered by the course. Special courses were planned in the other departments of the college.

The method of teaching such a course in the sciences presented problems. Should it be given by one individual, who would teach all the sciences, or should it be presented by representatives from each of the different departments, each one to teach during the time allocated for his particular subject? Strong objections were raised by staff members to the proposed plan of having one teacher for all of the sciences, because it was believed that he would have difficulty in presenting in an interesting and instructive manner the sciences outside his regular field. The question was raised regarding the professional advancement of the teacher having all of the sciences in a single course and being burdened with the responsibilities to such an extent that he would have little or no time for research. Such important factors as contacts in his profession and promotions within the university might be jeopardized by a heavy teaching load of numerous sections of a General Education course that would be required of all students entering the college. Another question was, should not the most experienced lecturer in each of the sciences be selected if the course was to be taught by representatives from each department, and how much of a burden would it be? Another facet for consideration was the additional staff and equipment needed in the department to provide this instruction in addition to the regular geology courses.

At that time some of the industry representatives were requiring a minimum of 50 hours of geology before the students would be considered for employment. Also, they were especially interested in those students who had a good background in mathematics, physics, and chemistry. Because of the need for thorough training in courses fundamental in the field of geology, the department had established a curriculum, prior to the setting up of the General Education program, that required at least 40 hours of geology, a minor in one of the allied sciences, and courses in mathematics, physics, and chemistry. Surveying, drafting, report writing, and speech were recommended. The difficulty of accommodating 50 hours of geology in a four-year curriculum was recognized, and consequently students were advised to seriously consider graduate work toward a Master's degree for the assurance of consideration for employment in industry.

There was much apprehension that the General Education courses would, in effect, be something added to the curriculum which might necessitate dropping many of the required courses or adding another year of study for the Bachelor's degree. The big question that came to mind was, should the training of geologists be sacrificed for a General Education program? The staff, who felt the responsibility of providing adequate training and consequently urged the retention of a strong geology curriculum, did not want the students to feel as one graduate from the Arts College expressed himself, "Education is grand, but you can't eat it!" This graduate was not in the physical sciences.

It is the writer's understanding that because of the General Education program

now in effect at the university the minor for the geology students has had to be dropped in order to include in the present geology curriculum the supporting courses in mathematics, physics, and chemistry; and other courses outside the department essential to the training of the geologist have had to be dropped. The regular requirements for the major have thus been maintained because of an increase in the total number of hours required for a Bachelor's degree. The solution of problems introduced by the General Education program has not been easy, and some problems remain to be solved.

Without the fundamental courses in geology and supporting courses essential to his academic training, the student is handicapped in seeking employment in industry and State and Federal Geological Survey work, or in undertaking graduate studies. What courses are considered fundamental to the training of a geologist? Undoubtedly opinion differs somewhat regarding the specific courses constituting an adequate academic training in geology, but in general there appears to be widespread agreement on the fields of geology that should be covered. In the writer's opinion the fundamental courses in geology, in addition to the introductory courses, are mineralogy, paleontology, stratigraphy, structural geology, petrography, map interpretation, and field geology. Adequate training in mathematics, physics, chemistry, and biology should be provided. Other supporting courses such as surveying, drafting, report writing, and speech add materially to the students' training.

Probably the impact of General Education varies to some extent with the geographic location of the school and the emphasis on the type of training that the students should receive. Although it may be generally conceded that certain General Education courses are desirable for some students, should these additional courses burden the curriculum for science majors? If the curriculum is expanded to include the General Education courses it seems reasonable to assume that the student will have to spend more than the regular four years to fulfill the requirements for an adequate academic training in geology.

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DON'T PENALIZE THE POTENTIAL GEOLOGY MAJOR*

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ABSTRACT. General Education is today's antidote for the abuses of the free election system of a generation ago. One of its devices is to substitute for traditional "content" subjects broad synthesis or "survey" courses occupying as much as half the class time of underclassmen, in many colleges. The effect on our profession is crippling; fewer geology majors with poorer academic grounding are available, in the face of rising demand for geologists and more rigorous training for them.

College geology shares with physics, chemistry, and biology the dual obligation of educating youth to think and also of providing pre-professional training. Unlike its "rivals," geology seldom enjoys a head start in secondary schools, and a thorough grounding in all these sister sciences is basic to the properly prepared geology major.

According to professional geologists, the ideal major should take at least one year each of college chemistry, physics, mathematics, and biology, as well as English, engineering, and a foreign language. However, the typical potential major is an underclassman with an open mind who doesn't know what he wants to do. If excited by the introductory course, he decides to major in geology perhaps late in sophomore year. He rarely has time for all the "basic" courses even if he does not take advanced R.O.T.C. He is seriously penalized if his early years were occupied with survey courses to the exclusion of more traditional content courses. The trend toward survey courses should be reversed to afford the potential geology major broader choice.

No compelling objection to the broad *ideals* of General Education has come to my attention. They were formulated most plausibly in the famous Harvard report of twenty years ago, to insure that a college student would become conversant with all great realms of knowledge rather than concentrate entirely on one narrow field as was possible a generation ago. There are three different devices for attaining this goal—the requiring of: (1) a broad sampling of traditional elementary or introtory courses in the realms of natural science, social science, arts, and the humanities; (2) a core of new interdepartmental or synthesis courses traversing broad realms but going deeply into none; or (3) a core of departmental survey courses such as "Origins of Mathematical Thought," "Geology and Human Affairs," and "The Nature of the Living World." The first device can accomplish everything without injury to a sound geology curriculum. It has evolved that the second and third devices, or a combination of them, may reduce the number of geology majors, or dilute their basic training, or both.

An extensive series of symposia beginning right after World War II (Geological Society of America, 1946) showed wide general agreement among professional geologists as to what a geology major should take for proper pre-geology pre-professional training. The list includes a minimum of one year each of college chemistry, physics, mathematics, and biology, as well as a foreign language (two are preferred), engineering, and English. These may be termed "auxiliary" courses, and

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their minimum total is seven. From a normal four-year schedule of twenty (year courses) this leaves a maximum remainder of thirteen for all other electives and all geology courses; and a remainder of only nine for men who elect advanced R.O.T.C. The desirable auxiliaries can perhaps be absorbed along with other aspects of General Education *and* basic geology courses, only if our "ideal" major gets and follows proper advice from the beginning of his freshman year. But this is rarely possible because geology is unique among the natural sciences.

A physics, chemistry, biology, biochemistry, or premed major usually gets seriously interested in secondary school. Indeed, many choose their colleges in terms of reputation in their chosen department or field. With rare exceptions, however, no entering college freshman today has had a head start in geology because it is not taught at the high-school level.

The typical *potential* geology major stands in the same spot I did thirty years ago. He or she is an underclassman with an open mind who doesn't know what to major in and is totally up in the air as to future career. He may have shown a bent for sciences in general but has had no geology yet. He may have demonstrated deep interest in nature and, on the other hand, little interest or ability in higher mathematics. Whether or not the latter be true it is no sign of inferiority. As Bucher (1941) put it:

> When capable men go into the so-called descriptive sciences, they do so not because of a weaker intellect, but because they are drawn by a love of tangible things. . . . The typical "geological" processes can not be studied directly by laboratory methods but only indirectly by their results; that is, by the methods of the historical sciences which are foreign and in large measure distasteful to the physicist [or mathematician].

If, for one reason or another, perhaps to satisfy a General Education requirement, our freshman or sophomore takes and is enthused by beginning geology, he decides to major in geology. This is almost the sole way for our profession to obtain recruits! But the decision may not come until late in sophomore year. It is then difficult to amass the recommended auxiliary courses even if, by use of device 1 (above), the embryo geologist has taken a catholic sampling of other sciences, engineering, English, and languages. In schools using devices 2 and 3, he is forced to by-pass vital tool subjects, or to satisfy college degree requirements with glaring professional deficiencies, or to change his major to one with few or no prerequisites.

The apparent conflict between General Education and pre-professional training is common to all sciences, but it is especially acute in geology, which alone cannot be begun in most high schools. Some say a "liberal" college of arts and sciences should not attempt even a pre-professional training. This seems indefensible unless liberal means impractical, vague, or unsuited to career use. To say that science is less liberal than arts or humanities is to express a prejudice, not a fact. It is usually espoused by non-scientific scholars who perhaps fear loss of enrollment and who commonly outnumber their scientific colleagues in faculty debates about General Education.

Let us assume that the purposes of General Education, the mastering of requisite auxiliary subjects, and the fundamentals of geology can all be attained in a four-year college. I believe they can be and should be. We who locate, infect, and teach geology majors have a dual obligation to education in general and to our institutions in particular *and* to the already undermanned profession. These obli-

gations can be met without conflict if both educationists and the profession understand each other's needs.

The value of survey courses to the ideals of General Education is questionable. It seems to me that the critical question is: "Can the purposes of General Education in underclass years be achieved without diluting the pre-professional training of those who may expect, after the normal four years of college, to go on to graduate work in science?" The answer is YES, but only *if* basic content courses are not crowded out of underclass years by survey courses.

Let us give the potential geology major a broad choice of truly solid introductory courses as a foundation upon which to specialize. Let us expunge from our curricula such watered-down and sugar-coated courses as "Geology for Arts Majors," "Chemistry for Non-Majors," and "Physics for Those Who Cannot Solve $2X = 10$ for X." Even worse, for all who deservedly expect underclass courses to bridge the gap between high school and a major concentration, are those interdepartmental surveys which serve as intellectual scatter shots aimed at none and destined to leave, at best, but faint imprints on able minds.

REFERENCES CITED

Bucher, Walter H., 1941, The nature of geological inquiry and the training required for it: Am. Inst. Min. and Metall. Engineers, Tech. Pub. n. 1377, p. 1–3.

Geological Society of America, 1946, Proceedings of conference on training in geology: Interim Proc. Pt. II.

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DEATH OF AGT PRESIDENT, STANARD G. BERGQUIST

Just before publication of this issue of the *Journal* word was received of the death, on March 31, 1956, of Stanard G. Bergquist, President of the Association of Geology Teachers. An appreciation of his work in behalf of the Association, as Vice President (1955) and President, will appear in the Fall 1956 issue of the *Journal.*

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IMPLICATIONS OF GENERAL EDUCATION FOR THE TESTING PROGRAM IN GEOLOGY*

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ABSTRACT. Geology teachers in a dozen eastern and central colleges who have responsibility for creating and teaching specially designed courses in science in General Education have modified their approach to geology courses as follows: They have (1) reduced stress on factual knowledge and increased emphasis on understanding, organization, and synthesis; (2) shifted from nicely contrived lectures to discussion of problems of applying concepts the student can learn from his own reading; (3) considered the student as a participant, not merely as a neutral observer; (4) redefined the objectives of the basic geology courses in the direction of a balance between being shown the tools and being taught how and when to use them; (5) provided for testing not only facts but skills, understandings, judgments, and appreciations.

Least progress has been made in the fifth step, testing. The average teacher still asks almost entirely for factual data, and the average undergraduate, no matter how fine the classes, will gauge his efforts toward ends stressed in the examinations. We must make concerted efforts to measure ability to select and organize data, quantify, judge relevance, recommend procedures, and relate geology to other phases of learning. This requires a clear formulation of teaching objectives and, for many teachers, a more thorough study of the types of questions best suited to testing various kinds of achievement.

The General Education movement, in its concern with objectives, has produced two major modifications of elementary geology courses in most colleges and universities. The most common of these is an adaptation of the conventional physical and historical geology course to include facets of interest and value for the non-science major who takes the course as a college requirement. The second modification is the creation of specially designed General Education courses in earth science consisting of a semester of geologic work plus a semester of selected studies from astronomy, geography, or other physical sciences. I am not inclined to include in either type the broad survey course in physical science, which has often been a condensed arrangement of rather superficial information and has failed to give meaning. Rather, I speak of a course for those students whose interests lie in the humanities and social sciences, who not only have had no strong science interest or background but are frequently prejudiced against any such study. It is the genesis and evolution of a course of this second type that calls for the best efforts among teachers and has frequently produced some of the best results, if student interest and willingness to work are to be taken as criteria.

Over the past two years I have talked with more than a dozen teachers in eastern and central institutions who have contrived specially designed courses in earth science for the general liberal arts student. Many of these men have modified their entire approach to teaching. The following summary is a subjective estimate of their changes in approach:

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1. Reduction of classroom stress on factual knowledge, coupled with increased attention to the student's motivation and to development of understanding and of ability to organize and synthesize.

2. Shift from nicely contrived lectures to class discussion of problems. These problems involve application of facts and concepts which the student has been able to learn from his own reading, for which he now becomes more highly motivated as his professor mingles scholarship with humanity and understanding.

3. Consideration of the student as a class participant, not merely as a neutral observer. Rather than being penalized for what he does not know, the student is encouraged to seek further information. This obligates him to do his own reasoning, as well as outside reading.

4. Rethinking of the objectives of the basic geology courses, keeping in mind (a) the need for a proper balance between being shown the tools of geology and being taught how and when to use them, and (b) the education of the individual as a whole being, in the light of his attitudes, imagination, and motivation.

5. Providing for testing not only facts but skills, understanding, judgments, and attitudes.

It is not my purpose to argue in support of the five headings above. I assume they comply with the broader purposes of education. A reminder from A. N. Whitehead (1929) is appropriate here:

> Thus the proper function of a university is the imaginative acquisition of knowledge. . . . The combination of imagination and learning normally requires . . . freedom from restraint, . . . some variety of experiences, and the stimulation of other minds diverse in opinion and diverse in equipment. . . . Apart from this importance of the imagination, there is no reason why business men, and other professional men, should not pick up their facts bit by bit as they want them for particular occasions. A university is imaginative or it is nothing—at least nothing useful.

However, there is a serious problem which I should like to make the main concern of this paper—namely, that little progress has been made in the field of testing. Judgment of this is based on a comparison of course syllabuses and stated objectives with sample examinations from the same courses. The average elementary geology exam is still heavily burdened with purely factual material, some of it—at least from the point of view of the general student—desiccated, fossilized, and thoroughly unretainable. The average undergraduate, no matter what the announced purposes of a course may be, will put his learning stress on the kind of information which he feels will be necessary to put him through examinations. Thus, thoroughly desirable classroom procedures may be vitiated by outmoded, impersonal, and unimaginative evaluation procedures.

Let it be understood that I am not opposed to the student's learning and memorizing essential factual material. But a student's score on a factual true-false test would reveal about the same grade distribution if he were tested on 100 statements or on half that number. Thereby time can be made free for questions which involve the selection and organization of material, quantification, judgment of relevance, recommendation of procedures, and the relation of geology to other phases of learning and living.

What, then, are some suitable types of test items, and how can we attempt to bring our testing procedures into line with progress we have made in teaching tech-

niques? It will help to re-examine our course objectives carefully. A specific and rather detailed statement of objectives (for each unit of the course, where necessary) will be found to be of much help in composing a good test. For example, suppose we hope to impart some skill in the use of the scientific method. Without attempting the difficult task of defining precisely what scientific method is, we may aim to give the student an operational concept with these characteristics which may be measured by examination responses:

1. Being curious and observant.
2. Being tolerant and broad-minded.
3. Recognizing that behind every effect there must be a sufficient cause.
4. Insisting upon accuracy.
5. Relying upon the tested results of reputable workers.
6. Learning to distinguish between prejudiced and unprejudiced opinions.
7. Demanding adequate evidence before settled conclusions are reached.
8. Suspending of judgment until all available facts of significance have been ascertained and analyzed.

Objectives for the various units of a course will be found to be most easily organized under the following four headings:

1. Informational—acquiring a literal knowledge of basic vocabulary; for example, from a unit on glaciation, recognition of the appearance of an esker, tarn, or varve.

2. Operational—the recognition of the basic process or function in standard circumstances; for example, the method of origin of esker, tarn, or varve.

3. Interpretive—developing the ability to weigh evidence, integrate, judge relevance, select pertinent data; for example, to compare the sedimentation process in esker and varve in terms of time, initial dip, or particle size.

4. Applicational—being able to meet a new situation in which a theory is offered to solve the problem at hand. Important factors would include the ability to find flaws in an argument, the attitude of the student, his creativity and originality, or his habits of accumulation of information. For example, how might we, in the field, distinguish an esker from a kame terrace?

In advanced courses additional objectives would include the more particular skills pertinent to geologic thinking. For a course with General Education emphases, objectives might stress also the unifying aspects of the sciences, such as the theory of probability, the procedures of empirical science, the linguistic aspects of science, cosmology, and the scope and limitations of geology.

With carefully defined objectives we have some rational hypothesis behind each question. This is the crux of the matter. The next step is obvious. We plot our objectives on a grid against exam questions (as we compose them). It is handy to use typewriter spacing as the ordinate grid unit on a permanent but detachable vertical strip of heavy paper fastened to a sheet of graph paper. Across the top of the graph paper we indicate exam questions by number. As we check questions against objectives, it is soon evident that purely informational questions are easiest to compose, and that the average exam may completely disregard the very essence of understanding because of being overloaded with literal information.

Additional help in composing questions to measure the less tangible objectives is suggested by a study of question type and format. With unlimited time and

patience for correction, the essay questions are superior to all others and surely they should be used more frequently by more teachers. It is probable that every hour-long examination should include at least some essay work, but enrollments and teaching loads being what they are, it is unrealistic and probably inefficient not to use other types as well. Essay questions do have additional disadvantages in that they are hard to score, involve partial credit, are not free from chance success, and may give the student a tendency to circumvent his lack of knowledge of a particular point. But they do measure certain objectives very well when carefully phrased, and then correction time is well spent.

The completion blank, or open-ended sentence type of question, fits operational objectives rather well. However, like true-false, multiple choice, and matching, the completion blank type may be overworked for informational purposes. If properly used, multiple choice techniques have value approaching the essay type. Ingenious variations of multiple choice type are being developed to measure interpretive and applicational objectives. Examples of these may be found in the *Manual of Procedures,* prepared by the American Council on Education (1951). An excellent source of helpful suggestions is an article on achievement tests by Walter W. Cook (1950). It is not possible at this time to exemplify the excellent multiple choice formats that are available. It suffices to say that our tests will not be very valid or reliable unless we observe the rules about length and difficulty of choice, and avoid absolutes such as *never, all,* and similar give-away words, and unless we use care in building our foils. These misleading answers should be set up deliberately to help diagnose types of errors in student thinking. Choices should include those which are too broad, too narrow, or too specific, and those that have confused time sequence, that confuse cause with effect, and that involve a near opposite of the best answer.

In view of the importance and value of good testing, I should like the AGT to consider the desirability of setting up some type of pool or clearing house for test items. Such a center could serve for an exchange of favorite questions and preferably should employ a professional in test construction to improve, validate, and broaden the function of this phase of teaching.

I shall conclude with a quotation from Dr. Walter W. Cook (1950):

> The greatest need in the achievement-testing field is for the development of types of test exercises consonant with evolving educational objectives. The statistical techniques for determining validity and reliability, for item analysis, and for expressing scores in meaningful ways have outrun the quality of the tests. The construction of items, which will measure and encourage . . . learning and which will stimulate achievement to capacity, is greatly needed in every field of achievement. To build such items requires rare insight into the meaning of education and the function of each subject area in modifying human behavior in desirable directions. When such tests are available teachers and students alike will work toward the clarified goals with greater efficiency.

REFERENCES CITED

American Council on Education, 1951, Manual of procedures: Cooperative study of evaluation in general education of the American Council on Education, February 1951, Michigan State College. (Private circulation only.)

Cook, Walter W., 1950, Achievement tests, *in* Encyclopedia of Educational Research, revised ed., New York, Macmillan, pp. 1461–1478.

Whitehead, A. N., 1929, Universities and their function, *in* The aims of education and other essays, New American Library of World Literature, Inc., New York.

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ARMY MAP SERVICE MAPS FOR COLLEGE USE

W. C. PETERS
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ABSTRACT. Some of the Army Map Service topographic maps of foreign areas are useful for laboratory work in geomorphology. Four maps of Greenland are recommended for their portrayal of glacial features, and four of New Guinea for their representation of coral-reef and other coastal features.

Laboratory work in geomorphology can be extended beyond the realm of U. S. Geological Survey quadrangle maps by the occasional use of U. S. Army Map Service sheets of foreign areas.

Detailed large-scale maps are reserved for use by the Department of Defense. There are, however, several series of topographic maps with scales of 1 : 500,000 and smaller which have been made available for civilian use. A list of index sheets to foreign maps approved for public sale may be obtained from the Army Map Service.[1]

Among the topographic sheets that include sufficient detail to be useful in geomorphology or physical geology laboratories are certain ones covering areas in Greenland and New Guinea. Topographic forms not generally seen on maps of United States areas are clearly shown. A few maps from each area are suggested here.

GREENLAND. The east, south, and west coasts are covered by *Series AMS C401,* scale 1 : 500,000. Date 1944. Price 75 cents per sheet. Topography is shown by form lines and "rock drawing." The following sheets are recommended:

1. Sheet NS 25 and 26-SE: *Suess Land.* An excellent portrayal of part of the ice-cap with remnants and tongues. There are nunataks, ice-dammed lakes, morainal lakes, deep glacial troughs, hanging valleys, and fjords. Medial moraines are well shown.
2. Sheet NP 21 and 22-3: *Fiskenaesset.* An edge of the ice-cap with tongues extending to the sea. An exceptionally clear coastal end moraine is included.
3. Sheet NR 21 and 22-5: *Godhavn.* A typical fjord coastline with glaciated valleys, braided streams, and ice-cap remnants.
4. Sheet NR 21 and 22-2: *Unbekendt Ejland.* A fjord coastline with ice-cap remnants.

NEW GUINEA. The island is covered by *Series AMS T401,* scale 1 : 500,000. Date 1942–43. Price 50 cents per sheet. Topography is shown by hachures. The following sheets are recommended:

1. Sheet S-A 53-2: *Manokwari.* Clearly defined fringing reefs and barrier reefs.
2. Sheet S-C 52-2 and part of SC 55-5: *Port Moresby.* Barrier reef, spits, and cuspate beach.
3. Sheet S-A 53-4: *Fakfak.* Fringing reef with tidal swamp. An offshore bar and bayhead bar are shown also.
4. Sheet S-C 56-4: *Samarai.* Atolls.

[1] Address the Map Distribution Division of the Army Map Service, Corps of Engineers, 6500 Brooks Lane, Washington 25, D. C.

BOOK REVIEWS

Petrographic Mineralogy. Ernest E. Wahlstrom. vii and 408 pp. John Wiley & Sons, Inc., New York, 1955. $7.75.

Petrographic Mineralogy is essentially *Igneous Rocks and Minerals,* by the same author, revised and enlarged to include sedimentary and metamorphic rocks. Sections on the universal stage, graphic presentation of data, and petrographic calculations have been added. *Petrographic Mineralogy* may be divided into four parts: (1) Microscopic and non-microscopic petrographic techniques. (2) Mineral descriptions. (3) Tables for mineral identification. (4) Composition, properties, and classification of igneous, sedimentary, and metamorphic rocks.

The discussions of techniques vary greatly in detail. Some techniques, such as spectrography and electron microscopy, are recognized as being too complex for a book of this scope and are summarized in two or three sentences. More common techniques such as heavy liquid separations are considered in more detail, and a plan of procedure is suggested. The new chapter on the universal stage and that on the graphic presentation of data and petrographic calculations are terse to the point that a student will need supplementary material in order to understand and use the techniques. The mineral descriptions include 124 minerals and mineral groups. This is an increase of 45 over *Igneous Rocks and Minerals.* The organization has been changed, and several groups such as the zeolites and the brittle micas have been summarized in tables which clarify the relations of the minerals within those groups. There are four sets of determinative tables. Table I is principally for use with thin sections and Table II with immersion media. Table II has been completely reorganized from its equivalent in *Igneous Rocks and Minerals,* and the range of indices of refraction of each mineral is plotted graphically in the manner of Johannsen's tables in *Essentials for the Microscopical Determination of Rock-Forming Minerals and Rocks* (that thin green book). Table III is a list of anisotropic minerals arranged in order of increasing birefrigence, with the color noted. Table IV, which is new in this book, is a classification of minerals according to habit. The composition, properties, and classification of igneous, sedimentary, and metamorphic rocks are discussed in the last three chapters of the book, with each rock type allotted a chapter of about 40 pages. These chapters are essentially summary statements with very limited classifications except for that of igneous rocks. Petrogenesis is not considered.

Professor Wahlstrom states in his preface that the book is designed for a one-semester course in petrography, following a course on the use of the polarizing microscope. The book does not seem adequate unless the student has had another course that has dealt thoroughly with petrogenesis, possibly a course in hand-specimen petrology. The use of multiple identification tables is to be applauded, and the summaries of non-microscopic techniques are helpful. A large number of references allows the student to locate supplementary information with a minimum of effort.

IRVING S. FISHER
University of Kentucky

Geologic Diagrams for General Geology. Robert L. Nichols. vi and 382 pp. Addison-Wesley Printing Corp., Cambridge, Massachusetts, 1955. (Not available for public purchase at present.)

Teachers of elementary geology will find this a unique book. It contains pages and pages of line drawings, block diagrams, and three-dimensional drawings, gathered primarily for the student but useful also for the inquiring pedagogue searching for new ideas in his presentation of the geological story.

The subject matter, except for a table of contents, is presented solely by sketches and diagrams, with a few tables and charts (8) to help. The arrangement follows the two-semester general geology course (physical and historical) as taught at Tufts University. With a hard cover, cloth bound in brown and blue with white lettering, 9 by 12 inches, this attractive book is intended for use as a notebook in lecture but may also serve in the laboratory. Most of the sketches have no labels, as the student is expected to supply these. Thirty-eight photographs on glossy paper introduce the viewer to numerous subjects in physical geology. These are followed by 552 sketches by the author and 441 diagrams taken from many published sources (all duly credited). Some occupy a full page, while others leave much room for notes or sequences of events. Cleverly interspersed throughout the book are 116 verse and prose passages of varying lengths, a few written by former Tufts students but most by famous scientists and poets—

all with a geological propensity, collected over a score of years.

When such a teacher as Nichols accumulates the line drawings sketched on his blackboards or in his examinations, the diagrams of others he has admired and used for years, and the photographs projected as illustrative material in his many lectures, and assembles them in one place, he has bestowed a singular gift upon his teaching profession. To liberally sprinkle with the poetry of men elevates such a work into the realm of art. In a sense this book is a pictorial record of a technique in teaching, for it depicts the approach of a man devoted to teaching, a man who spends much of his field time sketching what he sees, and most of his campus time sharing his experiences with his students.

SIDNEY E. WHITE
Ohio State University

Introduction to Physical Geology. Chester R. Longwell and Richard Foster Flint. x and 432 pp. John Wiley & Sons, Inc., New York, 1955. $4.95.

This book is the latest in the series of texts which have come to be known as the "Yale geologies." It takes the place of *Physical Geology* by Longwell, Knopf, and Flint, which still earlier took the place of the book with the same title by L. V. Pirsson. The present work is in most respects a new book, although its heredity can hardly be in doubt. Those who are looking for novel innovations or radical departures from well-proved practices will doubtless be disappointed. This might be termed a mature text in that it is the product of many years of trial and experience. Much of the philosophy of the book is outlined in the brief postscript on page 385.

The avowed intention of the authors has been to produce a "streamlined" textbook for an introductory course in geology written in "straightforward language with a minimum of technical terms." This means that the book has been condensed and simplified, particularly as compared with many of the other textbooks recently published in this field. I have come to think of this type of book as a *teacher's* text, i.e., one which gives the student a foundation on which a good teacher can build his own kind of course. This means that a course based on this text could be made as technical as the instructor desires, but along his own lines. On the other hand, it could be used just as easily with a group of non-majors with very wide and diverse interests. The flexibility of this book is also evident in the relative ease with which the order of consideration of the individual chapters can be changed, within reasonable limits, to suit the ideas of the instructor.

The first 56 pages, divided into four chapters, may be considered apart from the main body of the book. This section presents a general view of geology including discussion of the basic concept of uniformitarianism, the general characteristics of the earth as a whole, the nature of minerals and rocks, and above all the importance of time as a factor in geologic processes. The use of this section of the book presents some problems for the instructor, particularly with respect to the most economical use of available time. For example, it raises the question of whether it is better to spend a few extra days establishing good perspective by a thorough consideration of this section at the start of the course, or to skim through it very rapidly and refer back to it from time to time later. Chapter three may also present more specific problems as to just how far to go with a consideration of rock varieties early in the course, when much of the related material is presented later. For example, sedimentary rocks, described in pages 33 to 35, are given a much fuller discussion in chapter 16, to say nothing of the reference material in Appendix B. In other words, the first four chapters open up so many phases of the subject that there may be a temptation on the part of the instructor to expand some of these unduly at the expense of time needed later on for a more intensive study of the same topics.

The main body of the text, consisting of seventeen chapters, follows what we have come to think of as a fairly conventional or standard arrangement of topics, although a few subordinate variations may be noted. For example, discussion of stream activity in arid lands is separated from other phases of stream activity and combined with a description of wind work in chapter 13. This tends to bring together consideration of various processes which operate in arid and semi-arid regions, although on the other hand the considerable effect of wind work along shores and in certain river valleys tends to be minimized because of this arrangement.

Several of the chapters open with the description of a relevant case, e.g., Parícutin volcano in chapter 5, the Frank landslide in chapter 7, or a hypothetical stream as in chapter 8; each case is then used as a base from which to develop general principles in the discussion which follows. This manner of treatment should make the subject more realistic to the student, and one wishes that it were used even

more extensively throughout the book since it would repeatedly demonstrate to the beginner that field observations are the real foundation of the science.

Episodes in the historical development of geological science appear here and there through the book in sufficient numbers to give the student at least some impression of the background of evolution of our present ideas. A great many students seem to be averse to paying any attention to this side of the subject, but on the other hand instructors can keep on trying!

The illustrations in this book deserve special comment, since the authors have made a consistent effort to overcome the common failing of illustrations in introductory textbooks, namely, the failure to convey an obvious message to the beginning student, however clear they may be to the professional. A very large percentage of the pictures have superimposed labels, lines of demarcation, and reference scales, all of which help clarify the purpose of the illustration. In spite of this effort there are still some pictures which may puzzle inexperienced students, e.g., figures 7–10, 8–12, 11–6, 13–6, and 18–6. One can not help but wish for a few more summary diagrams like the one showing "Kinds of natural basins" on page 174. A physiographic diagram of the United States and a physical map of the world are included as end papers for convenient reference.

This text follows what seems to be the modern trend in reducing the descriptions of geomorphic cycles, as such, almost to the vanishing point. This serves to de-emphasize specific stages, and to one who has seen innumerable students learn to describe individual stages without ever seeming to grasp the fundamentals of the whole concept this would seem to be a step in the right direction for beginners. Basic information on the evolution of landforms is included under such headings as "Sculptural Evolution of a Land Mass" (pp. 146–150), "Sequence of Sculptured Forms" in arid lands (pp. 221–223), and "Sculptural Evolution of Coasts" (pp. 252–254).

Several controversial subjects are introduced to the student without prejudice: these are problems such as the origin of granite (pp. 308–309), the causes of mountain building (pp. 353–356), the causes of glacial ages (p. 202), and submarine canyons and turbidity currents (pp. 235–239). The basic attitude which the student should take in approaching any of these subjects is well discussed on pages 20–21, although the instructor is still left much to do in this field.

Since this book makes no claim to new and startling innovations, its choice as a textbook, over others covering the same field, would seem to rest chiefly on (1) simplicity of language, (2) brevity, and (3) flexibility. On the other hand, possible criticisms may come from those who prefer either a text with more window dressing and elaboration, or one with more emphasis on the quantitative aspects of geology.

In summary, this text seems to offer the student a solid *core* of basic material. The rest is up to the instructor.

ELWYN L. PERRY
Williams College

SHORT REVIEWS

Glossary of Selected Geologic Terms with special reference to their use in engineering. William Lee Stokes and David J. Varnes. xii and 165 pp. *Colorado Scientific Society Proceedings,* Vol. 16, Denver, Colorado, 1955. ($3.50 cloth bound, $2.75 paper bound). As the title indicates, this glossary was compiled chiefly for civil engineers and workers in related fields, and its 2670 entries cover the field of general geology. In preparing the definitions and accompanying explanations, 112 references (listed in the Introduction) were consulted. This glossary does not pretend to provide an exhaustive coverage of the ever-growing list of geologic terms, and the compilers admit that "both the selection and the treatment are to a considerable degree subjective and, therefore, not uniform." This is inevitable, and nearly every user will probably wonder why some terms were included and others omitted. However, the glossary should prove very useful to the non-geological users for whom it is intended, and to many geologists as well.

Handbook for Teachers of Earth Science. Mildred Fisher Marple and Walter C. Brown. vi and 61 pp. Ohio Division of Geological Survey, Information Circular 15, Columbus, 1955. Members of the Association of Geology Teachers often complain of the two following facts: (1) that in so many elementary and high schools there is no teaching of earth science, and (2) that even where it is offered the teachers are so often inadequately prepared in the earth sciences. Marked improvement in both regards could be hoped for if more of us would do as much as have the authors of this handbook to stimulate pre-college interest in earth science in our respective states. After a brief discussion of the values of

earth science, there are sections on minerals, rocks, fossils, earth history, surface features, and mineral wealth, all emphasizing Ohio geology. Other chapters deal with suggestions regarding how to carry out field trips and how to do rock cutting and polishing; specific projects to undertake in the field (with emphasis on those suited to Ohio) and at home; and the names of organizations and individuals in different parts of Ohio who can give help on earth science matters. A bibliography and short glossary complete the handbook. It is illustrated with photographs, diagrams, and maps.

The Principles of Chemical Weathering. W. D. Keller. 88 pp. Lucas Brothers Publishers, 909 Lowry St., Columbia, Missouri, 1955. ($2.75). As is indicated in its sub-title, this is "an integrated review of the principles of chemical weathering as taken from the literature, and the relation of weathering to certain aspects of geology, pedology, and civilization." It discusses the processes and agents of chemical weathering, the chemical reactions involved, and the products, both soluble and insoluble—all this in much more detail than is found in most textbooks. In addition it brings out the significance of chemical weathering to man, especially in terms of soil formation and the effect of different types of soil on human nutrition. The bibliography lists works dealing with both the technical aspects of the subject and the applications to human problems. The author compiled this material for use in his undergraduate geology classes at the University of Missouri, but it should be helpful to graduate geology students also, and to workers in related fields, such as geography and biology.

Ohio Fossils. Aurèle La Rocque and Mildred Fisher Marple. v and 152 pp. Ohio Division of Geological Survey, Bull. 54, Columbus, 1955. ($0.97, plus $.03 tax for Ohio residents.) This book is an introduction to paleontology as well as a guide to fossil collecting in Ohio. Its first 43 pages include a discussion of the nature of fossils; their uses; instructions on collecting, preparing, and naming fossils; an outline of the classification of plants and animals; and a brief geological history of Ohio. In the remainder of the book are descriptions of the commoner fossils found in each geological system represented in Ohio. Line drawings and keys serve as guides in fossil identification. Good collecting localities are described, and a long bibliography is given. Amateur collectors and geology students should gain much help and enjoyment from the use of this book.

Atlas of Paleogeographical Maps of North America. Charles Schuchert, with an introduction by Carl O. Dunbar. xi and 177 pp. John Wiley & Sons, Inc., New York, 1955. ($4.75.) Included in this atlas are 84 paleogeographic maps of North America (58 for the Paleozoic, 18 for the Mesozoic, and 8 for the Cenozoic), presenting data compiled by Charles Schuchert up to the time of his death in October, 1942. With each map is a list, as complete as possible, of the chief stratigraphic units present in each area of outcrop. A seven-page index lists these formations and the maps on which they are shown.

Water in Kansas, 1955. A Report to the Kansas State Legislature, submitted by Kansas Water Resources Fact-finding and Research Committee. 216 pp. Under the chairmanship of Frank C. Foley, Director of the State Geological Survey, the above committee and its staff have prepared an extensive report on the water problems of Kansas. Geological aspects of water supply are not treated in great detail, but teachers wishing to demonstrate the human significance of geological studies of water supply will find much helpful information here.

Proceedings of the Conference on Latin-American Geology, March 29–30, 1954, co-sponsored by the Department of Geology and the Institute of Latin-American Studies, the University of Texas. Fred M. Bullard, editor. vi and 103 pp. The University of Texas, Austin, 1955. This two-day conference brought together workers in the field of Latin-American geology from both the United States and Latin-American countries themselves, "to survey the present state of knowledge and to focus attention on those areas in which more investigation and research is needed." Included on the program were nine papers, of which five are printed here in full and three in abstract form. Topics dealt with in the full-length papers include petroleum geology and metallic ore reserves of Mexico (with a separate geologic map of eastern Mexico, 1952, on the scale of 1 : 3,500,000); geological development of the Colombian Andes; the northern Maturín Basin of eastern Venezuela; and mineral deposits of Brazil.

TRANSACTIONS
OF THE
ASSOCIATION OF GEOLOGY TEACHERS

MINUTES OF THE BUSINESS SESSION, FIFTH ANNUAL MEETING, NOVEMBER 7, 1955. The meeting, held at the Roosevelt Hotel, New Orleans, was called to order by President Shideler at 1:45 P.M. Inasmuch as the minutes of the last Annual Meeting had been printed in the *Journal of Geological Education*, their reading was dispensed with.

President Shideler and Vice President Bergquist made brief informal reports. Secretary Bates then reported and, in the absence of Treasurer Higgins, read the Treasurer's report. It was moved, seconded, and carried that these reports [see below] be approved.

President Shideler read a brief statement from Editor Van Burkalow, in which she stated that a new method of printing was being tried out and urged members to contribute material for publication in the *Journal*.

Kurt E. Lowe, reporting for S. W. Lowman, stated that work is continuing on the Directory of Geology Departments and that it is hoped to issue it in 1956.

Richard M. Foose, representative to the AAAS Council, stated that he had been on the West Coast during the past several months and hence had been unable to attend Council meetings.

It was moved by C. H. Behre that a resolution of sympathy and an expression of gratitude be sent to the family of Past-President Leland Horberg, and that a committee of three be appointed to draft this resolution. The motion was seconded and carried. Kurt E. Lowe stated that a memorial to Dr. Horberg will appear in the *Journal of Geological Education*.

The election of members to the 1956 Committee on the Neil Miner Teaching Award then followed. C. H. Behre suggested that continuity of membership on this committee was desirable, and he moved that one new at-large member be elected annually instead of three. This motion was seconded. Kurt Lowe pointed out that a certain continuity already exists, inasmuch as the last Past-President is a member, and he presented an amendment to the effect that two new members be elected and one stay over. This modification was accepted by Behre and the seconder, and the amended motion was seconded and passed. The following nominations were made: John B. Lucke and Richard P. Goldthwait (new members) and C. B. Moke (hold-over). It was then moved, seconded, and passed that the nominations be closed and that the Secretary cast a unanimous ballot for the above nominees.

On the request of President Shideler, Secretary Bates then presented the Neil Miner Teaching Award for 1955 to Professor Alfred O. Woodford of Pomona College. Professor Woodford made a brief response, "What Is Geologic Truth?" [see pp. 5–8] in which he analyzed the validity of some of the assumptions that geologists are wont to make.

Secretary Bates announced that the Executive Committee had designated Richard M. Foose an AGT representative to the 1956 International Geological Congress and would like to know of other members who plan to attend so it could name a second representative.

The Secretary also stated that an organizational meeting of the Southeastern Section was to be held immediately following the afternoon symposium.

There being no further business, the meeting adjourned at 2:33 P.M.

Respectfully submitted,
ROBERT L. BATES, *Secretary*

REPORT OF THE SECRETARY. Routine matters of correspondence were carried on during the year, and the secretary attended a meeting with the secretaries of other geological organizations at the GSA House in New York at the time of the AAPG meeting in March.

In addition, four items are reported on separately, as follows:

(1) *Membership*. The roll as of last March 1 totalled 374. During the year we lost, through dues delinquency, resignation, or death, 12 members; we gained 29 new members. As of November 7, total membership is 391. A membership list was made up early in the year and sent to members of the Executive Committee and to all Section officers. A card index of members was completed and is kept up to date in the Secretary's file.

(2) Amendments to the Constitution. Two of these were submitted to the membership by mail and both were adopted. One changed the make-up and time of election of the nominating committee; the other changed the composition of the Executive Committee. Copies of these

amendments, for insertion into the Constitution, are available.

(3) Affiliation with the AAAS. Largely as a result of spadework done by previous officers, early in 1955 the AGT became formally affiliated with the AAAS. Richard M. Foose was appointed our representative on the AAAS Council.

(4) The Secretary apologizes to the membership for neglecting to see that a slate of candidates was prepared to present to the meeting at this time, as prescribed in the Constitution. A slate is now being made up and it will be circulated to the full membership by mail ballot within a few weeks. [Edit. Note: For names of the national officers elected by this ballot, see inside back cover.]

ROBERT L. BATES, *Secretary*

TREASURER'S REPORT. At the Annual Meeting a provisional financial statement was presented, for the period from January 17 to October 27, 1955. That is now superseded by the following financial statement for the year.

FINANCIAL STATEMENT, JANUARY 17, 1955 to JANUARY 24, 1956

Balance brought forward, January 17, 1955		$ 894.55
Income, January 17, 1955 to January 24, 1956		
Journal of Geological Education sales (current & back issues)	$ 609.10	
" " " " reprints, Vol. 3, No. 2	98.00	
National dues (current and back payments)	473.00	
Section dues	4.00	
Held for Northwestern Section $3.00		
Far Western Section (forwarded) 1.00		
Total income	$1184.10	$1184.10
Total credits, as of January 24, 1956		2078.65
Expenditures, January 17, 1955 to January 24, 1956		
Journal of Geological Education: printing, envelopes, postage (includes $315 for Vol. 2, No. 2, Fall 1954)	1271.86	
Officers' expenses	141.31	
Authors' reprints, *Journal*, Vol. 3, No. 2	96.97	
Miscellaneous (Digman scroll, Neil Miner awards, etc.)	35.09	
Total disbursements, as of January 24, 1956	1545.23	1545.23
Balance on hand, January 24, 1956		533.42

Respectfully submitted,
C. G. HIGGINS, *Treasurer*

NOTES AND NEWS

PROSPECTING FOR OHIO MINERALS. John H. Melvin, Chief, Division of Geological Survey, Department of Natural Resources of Ohio, announces the beginning of a survey of the mineral collecting localities of Ohio. The project is directed toward the study of mineral occurrences where the amateur collector can find stones worth collecting. All mineral enthusiasts who know of such localities are asked to help by sending information concerning them for the Survey files (credit will be given). Address all communications to the Division of Geological Survey, Room 106 Orton Hall, The Ohio State University, Columbus 10, Ohio. When enough material has been assembled it will be published in booklet form.

SUMMARY OF JOURNAL PAPERS. Maurice B. Rosalsky, Secretary-Treasurer of the Eastern Section of AGT, has compiled a classified list of the papers published in the *Journal* during its first five years of existence (Vol. 1, 1951–53; Vol. 2, 1954; Vol. 3, 1955). The following fields have been represented, with the number of papers in each given in parentheses: Philosophy of geology teaching (8); teaching methods in class, laboratory, or field (11); outlines of geology courses (8); earth science in grade and secondary schools (5); visual aids in geology teaching (14). Any member wishing to see the list may obtain a copy from Maurice B. Rosalsky, Department of Geology, City College of New York, 139th St. and Convent Ave., New York 31, N.Y.

The ASSOCIATION OF GEOLOGY TEACHERS was founded in the Middle West in May, 1938. In November, 1951, it was organized as a national association, under which there are at present six organized regional sections: Central, East Central, Eastern, New England, Far Western, and Southeastern. An annual meeting of the national association is normally held in the fall, and sectional meetings are held in the spring.

The purpose of the Association, as stated in its Constitution, is "to foster improvement in the teaching of the earth sciences at all levels of formal and informal instruction, to emphasize the cultural significance of the earth sciences, and to disseminate knowledge in this field to the general public."

Anyone concerned with geological education, formal or informal and at any age level, is invited to apply for membership. *Inquiries should be addressed to the national secretary,* C. E. PROUTY, Department of Geology, University of Pittsburgh, Pittsburgh 13, Pennsylvania.

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